Abstract

Voltage stability is the ability of the power system to maintain steady acceptable voltages at all the buses in a system under normal operating conditions and after being subjected to a disturbance. The increased consumption of electricity without the augmentation of the necessary transmission infrastructure has resulted in the overloading of the transmission lines. As a result, the transmission lines operate near the steady state stability limit. The transmission of large amounts of power through the lines results in the large voltage drops in the lines. Sudden disturbances like line or generator outage and fault in the transmission lines may occur because of natural or man made causes. Under the above mentioned conditions, the transmission system may not be able to supply the load demand. This results in drops in the system bus voltages which may be sudden or progressive. If the necessary remedial measures are not taken, then this may lead to blackout or collapse of the whole system. As a result of a number of voltage stability incidents reported from various countries, there is a widespread interest in understanding, characterizing and preventing this phenomena. This thesis is essentially concerned with analyzing the existing methods and the development of new methods for the assessment of voltage stability of power systems.

We examine four existing methods for assessing voltage stability with regard to the computational effort involved in their calculation, the useful information we get by using them, their relative effectiveness in assessing the voltage stability and their consistency in predicting the voltage stability of the system. We also study the impact of the system conditions on several of these indices. Further, we propose a set of new indices which provide information similar to the conventional indices but are slightly different. The generalized circle diagram approach proposed earlier to study the variation of the system variables with respect to the independent node parameters is shown to be adoptable for finding the voltage stability limit of a system. It has been shown that the well known continuation power flow method used for voltage stability analysis is identical to the generalized circle diagram approach. A computationally simple approach, based on the Thevenin equivalent of the power system is used to determine the loadability limit of a system. In the continuation power flow method, it is inherently assumed that only one generator responds to the real power load increase of the system. However, an alternate view is presented where all the generators respond to the real power increase in the system and an algorithm is proposed to realize this condition. Using this algorithm, the generation pattern of the system is modified so as to increase the loadability limit of the system considerably.

The origin of the voltage instability in power systems can be traced to the load characteristics. Induction motors constitute a significant proportion of the total industrial and residential loads. Two algorithms that are useful to study the voltage stability of systems having induction machines have been presented and validated. These methods are based on the induction machine static equations. The first method is useful in assessing the impact of network disturbances on voltage stability and the second facilitates the computation of the loadability limit. A criterion has been proposed to find the stability limit, stable and unstable operating regions for a system considering various types of induction motor loads on the basis of which, a practical algorithm is proposed and validated to determine the stability of the induction motors driving different types of loads in a large power system. In addition, a method is developed to determine the stability aspects when the constant torque loads and the constant input power loads driven by induction motors operate in a power system, which contains other types of loads like the constant $P - Q$ type of loads. Switching capacitors at the induction motor terminals is one of the ways by which voltage instability occurring due to the induction motor loads can be prevented. A new technique is proposed wherein knowing the capacitance and the slip at the instant of switching, the rotor dynamics following the switching and the existence of a steady state operating point following the switching can be predicted. This approach can be used to choose appropriate capacitances to be switched at the induction motor terminals to prevent its stalling following a sudden load disturbance.